ADVANCED TECHNIQUES AND NEW HIGH RESOLUTION SAR SENSORS FOR MONITORING URBAN AREAS

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1. ABSTRACT

Differential Interferometric SAR (DInSAR) stacking techniques [1] [2] and, particularly, Persistent Scatterers Interferometry (PSI) techniques [3] are commonly used to monitor slow deformation in urban areas such as those associated with underground excavations, water extraction, etc. Application examples with data acquired by medium resolution SAR sensors, such as those onboard ERS, Envisat and Radarsat satellites are given in the current literature showing even the possibility to measure building collapse precursors.

The availability of new high resolution SAR sensors, which are characterized by higher spatial resolutions and revisiting frequencies, see for instance the COSMO/SKYMED (CSK) constellation and TerraSAR-X (TSX), provide an important advance of the active microwave radar remote sensing technology from the space which must be complemented by the development of new and more advanced processing algorithms able to deal with a dramatic increase of data and extract at the same time more and more accurate information.

But for some intermediate processing steps related to the selection of candidate pixels to the radar monitoring, DInSAR stacking and PSI techniques use only the phase information of the received signal. This is a direct consequence of the assumption that only a dominant scattering mechanism, which can be accurately located and monitored, is present within each radar image pixel.

In areas characterized by a high density of scatterers such as, for example, urban areas where buildings, walls and other manmade structures show a complex vertical structure, the single scatterers assumption [4] may limit the accuracy of the reconstruction and in some cases prevent the detection of scatterers due to the so called layover effect. First analysis of data acquired by the new generation high resolution SAR systems are showing that the layover in urban area is even more pronounced with respect to the data acquired by medium resolution SAR

sensors such as those onboard the ERS and Envisat satellites. There are at least two reasons explaining such an effect:.

a) the increase of resolution makes the layover associated with vertical structures distributed over more image pixels (folding of vertical structures);

b) the increase of resolution increases the signal to clutter ratio and therefore the number of persistent scatterers [5]: they can be located on the façade, on the roof and on the ground surrounding the buildings. The probability that different scatterers may interfere in the same azimuth range pixel therefore gets higher.

An example of how dramatic becomes the layover effect in these new high resolution SAR images is shown in Fig 1. The image on the left shows an orthophoto of the area under investigation as visualized in Google Earth, corresponding to a tall building (the Mirage hotel) located in Las Vegas (USA), about 90 meters high, while the image on the right is an amplitude TerraSAR-X image of the same building.

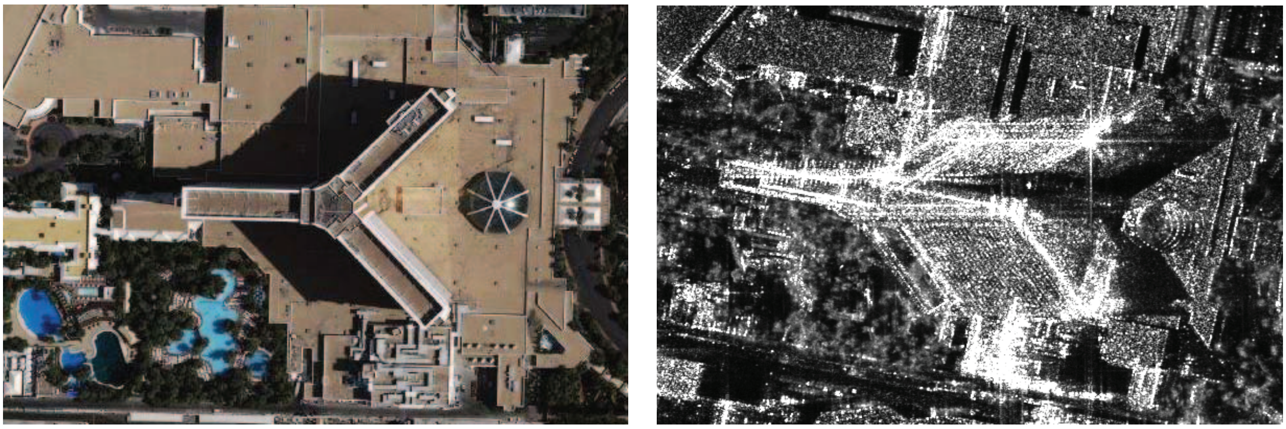

Fig. 1: (left) Google Earth image of a tall building in Las Vegas (USA), (right) TerraSAR-X amplitude image .

Fig.1 shows how the increased resolution makes the layover effect induced by the façades distributed over a large number of pixel: the building is folded on the ground toward the west direction (left). Since interference between the building façade and the scatterers on the ground is expected, in this condition the assumption usually performed in classical, phase only based PSI approach of a single scatterer per pixel is no longer suitable: classical interferometric techniques are not able to distinguish targets or, at least, they might only detect only the dominant scatterer.

A contribution to mitigate such an effect and resolve the signal interference is provided by the so called SAR Tomography technique (3D Imaging) [6], [7], including its extension to the velocity direction, known as Differential SAR Tomography or 4D imaging [8], [9].

By exploiting both the amplitude and the phase information of the signal received in repeated orbits of the satellite, 3D and 4D SAR imaging techniques are able to reconstruct the scattering profile along the elevation direction (3D) and in the elevation/mean deformation velocity plane (4D). Tomographic techniques allows first of all a higher accuracy [10] with respect to phase-only based interferometric techniques, such as PSI, in terms of detection, localization and monitoring of dominant scatterers. Secondly, it allows separating scatterers located at different elevations, and also moving with different velocity, interfering in the same resolution cell. Then, the possibility to separate contributions from different targets interfering in the same pixel due to the layover phenomenon means increasing the number of monitored targets.

This presentation aims to discuss examples of the application of the 4D imaging technique to real spaceborne data. We show the results of applying 3D and 4D imaging technique to data acquired by the ERS and ENVISAT satellites and we compare them with first results obtained on high resolution TSX data.

11. REFERENCES

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